The Role of Liquefaction in Disrupting Aquitards

Glendale GSU Alice Campbell ...But the contamination is going right through your "clay" layer like it's not even there.

"It's all those old longperf. ag wells..."

"The site is underlain by an extensive clay layer, the "A" clay, which prevents contaminant migration to deeper aquifers..."

The plume has remained sable for 5 years...

Yes, but it's moved down 100 feet...

Yes, but where are they, and how did they move all that water through those little bitty holes?

Quick Review of Calif. Hydro

Structural Troughs
Bounded by Active Faults
Unconsolidated Basin Fill
Confinement increases with depth
Pleistocene had 4 stages, with changes in depositional environments

Hydrogeology Review

- Basin recharge at margins, forebays, and some surface
- Natural discharge was to ocean
- Current discharge by pumping
- Seawater Intrusion
- ENSO drought/ rainy cycles (22-yr)
- Rare cyclonic storms (1862)

Other Facts

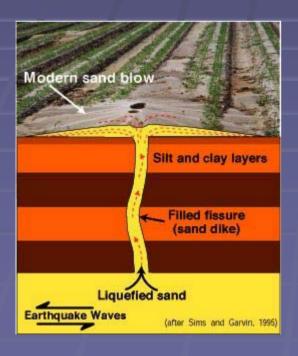
- Turbine pump introduced in 1930
- Basins pumped down
- Subsidence (worst at discontinuities)
- Evidence of deep migration of contaminations, especially old stuff
- Areas with little horizontal plume travel

Geology of Sand Boils

- Sand Dunes (USCS SP, medium grained)
- Other loose fine sands/silts
- Saturated, less than 50' burial
- Burial beneath playa lakes/extensive flood deposits/ delta deposits.
- Heavy shaking (Modified Mercali >7)
- Clay ripups entrained as little clay balls

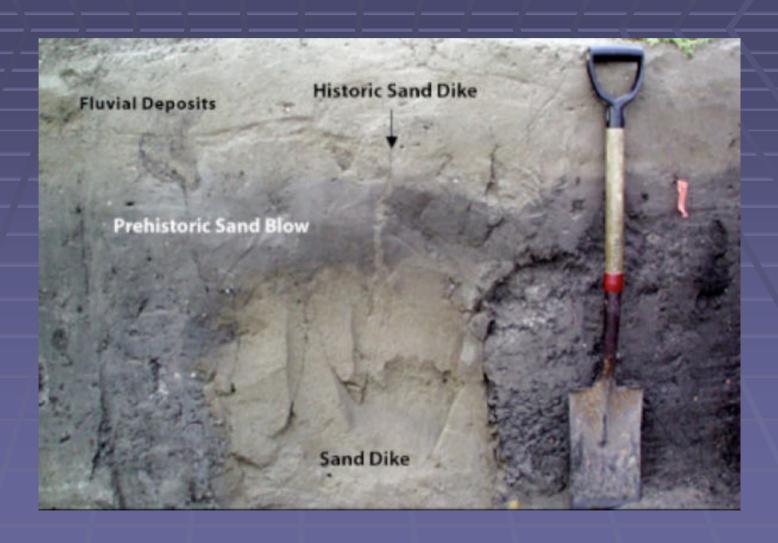
Sand Boil

Pajaro River, CA, Loma Prieta Earthquake 1989





Section Through Boil



Another Loma Prieta Boil



Near New Madrid, MO (ca 1811)



Near Malden, MO



NAS Lemoore



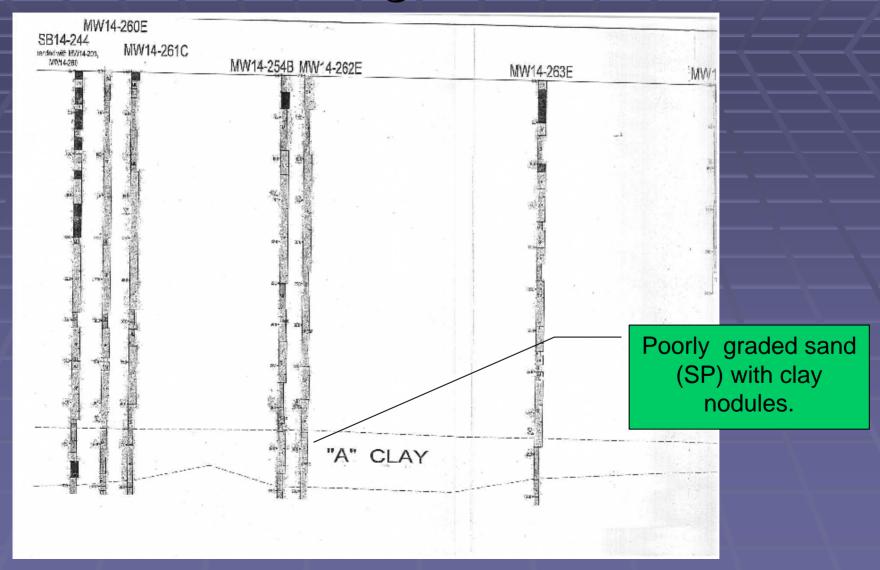
East of NAS Lemoore



Southwest of NAS Lemoore



Section Through NAS Lemoore



MW-262E

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C									Job Number: G1058.4101.15909
		H							Site: NAS Lomoore - Site 14
L									Orifling Company: RSI
Te	Tetra Tech EM Inc.								Orlilling Method: Sonic
									Sampling Method: Continuous Core
									Orlilling Date(s): 8-29-2005
-	1			_	T m	-	_		Logged By: John DeAngelis
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2.0				1	1	1	42		
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95	3.6	-	_	-	-	59			

Poorly graded sand (SP) with clay nodules.

Los Angeles River Floodplain

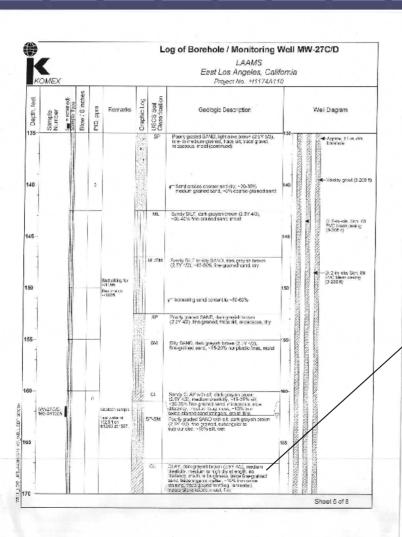
Areas indundated by 1862 Cyclone





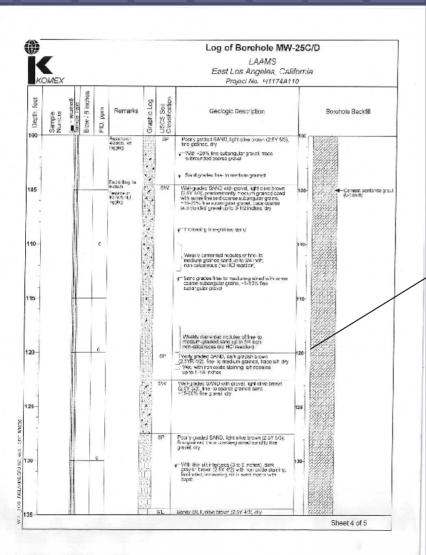
- Ground Failure during Long Beach earthquake
- How deep do those cracks go?

Boring Log Near East Los Angeles



Clay....trace gleyed mottling, laminated, macro-slickensides.

Another Boring Log Near East Los Angeles



SP, fine to medium, ...silt nodules up to 1-1/4 inches....

The Corcoran Clay is A Barrier to Vertical Flow... Right?

Early investigators thought that the Sacramento Valley contained a single unconfined aquifer and that the San Joaquin Valley contained an upper unconfined to semiconfined aquifer separated from a lower aquifer confined by the Corcoran Clay or "E-clay" (fig. 78). However, recent investigations indicate that the Central Valley contains a single heterogeneous aquifer system that contains water under unconfined, or water-table, conditions in the upper few hundred feet; these conditions grade into confined conditions with depth. The confinement is the result of numerous overlapping lens-shaped clay beds. Geophysical well logs indicate that the "E-clay," although probably the largest single confining bed, constitutes only a small percentage of the total thickness of clay layers in the aquifer system. This indicates that the significance of the "E-clay" as a barrier to vertical flow may have been exaggerated. Further, the difference in hydraulic head directly above and below the "E-clay" is small when compared to head differences within intervals of the deep parts of the aquifer system.---USGS

Evidence for Discontinuities

- Boring logs: Are the logs high-quality? Do the USCS names match the supporting data, esp. lab data?
- Sections: Playa lakes are laid down flat. Do the sections show horizontal layers?
- Are the head differences small across adjacent aquitards?
- Are there large inorganic chemistry changes? (especially salinity)
- Are there unusual/discordant materials such as clay balls in sand? Slickensides?

Conclusions

- Liquefaction, ancient or current, may play a part in creating vertical conduits.
- But it's not the only player.
- Look for clay balls in poorly graded fine-tomedium sand.
- No depth limit for older units

Quiz

Is the Present the key to the Past?